Evaluation of Anti-Fouling Materials for Optical Sensors

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LONG-TERM GOALS

Evaluate biocides for optical sensors that keep surfaces maintenance-free when exposed in marine-estuarine environments for periods ranging from weeks to months.

OBJECTIVES

Screen candidate materials in laboratory experiments. Design experiments for natural seawater exposure to correlate loss of quality optical measurements with surface-related phenomena, including microfouling.

APPROACH

The most promising candidates from laboratory testing (citric acid and capsicum) were selected for natural seawater exposures. In addition, benzylalkonium chloride and a combination of the three materials were incorporated into a proprietary epoxy (Advanced Polymer Sciences, Avon Park, OH). Biocides were provided by Magellan Companies, Inc., (1051 Planter Place, Mt. Pleasant, SC) as specified in NCRADA-NRL-SSC-97-001, Biocides for Ocean and Littoral Application, and applied at Advanced Polymer Sciences. Optical surfaces were selected because of their use by instrument manufacturers. Antifoulants were applied to the disks (5.08 cm diameter and 0.3 cm thick) of the following materials: G1 fused quartz used by WETLabs Inc., Philomath, OR; clear acrylic used by HOBILabs Inc., Watsonville, CA; and white acrylic #2447 used by Satlantic Inc., Halifax, N.S. Antifoulants were mixed into epoxy resin at a 3 to 5% biocide loading, applied by brush to one side of the disks and cured at room temperature.

WORK COMPLETED

Four replicates were prepared for each antifoulant on each surface. Two uncoated blanks were used for each set of materials for a total of 72 samples. Samples were exposed at Naval Research Laboratory Corrosion Research Facility, NAS Key West, Key West, Fl. Replicates and blanks were mounted in a separate frame for each material and placed in a continuous flow natural sea water tank. A submersion box was developed that allowed samples to be exposed without direct contact with the air-sea interface. Prior to immersion and at interval over 90 days each sample was scanned with a dual beam spectrophotometer, Kontron UVIKON 860 from 400 to 800 nanometers at 1 nanometer intervals and absorbance values recorded. After 90 days samples were collected, preserved in 4% glutaraldehyde and transported to NRLSSC for photography and environmental scanning electron microscopy (ESEM). Raymond Burge

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designed and fabricated the exposure rack and submersion box. Clark Kennedy emplaced samples and recorded optical data. Richard Ray produced photographic documentation and ESEM images. All participants are NRLSSC employees.

RESULTS

Little difference was detected between uncoated quartz and clear acrylic materials. Data for white acrylic material indicated scattering that prevented comparisons with the other materials. Coating quartz and clear acrylic optical windows with antifoulants changed spectral properties. Average absorption values for antifoulants on quartz in air indicated spectrally flat low absorbency from 500 to 800 nanometers. The blue end of each spectrum showed a rapid rise in absorbency from 500 to 400 nanometers, consistent with organics in the epoxy resin. Increase absorbency after brief exposures were dueto water uptake by epoxy and/or adsorption of dissolved organic material. Increases in absorbance near 400 nanometers over weeks and months for all surfaces was consistent with accumulations of organic materials. No antifoulant material was better than clean uncoated quartz and clear acrylic surfaces in retarding accumulation of organic materials over the time of this experiment. All surfaces were dominated by abiotic accumulations of diatom frustules, aggregates of aluminosilicate clays and amorphous colloidal material.

IMPACT/APPLICATIONS

Glass and clear acrylic surfaces coated with biocides/biostats impregnated epoxy did not remain free of surface accumulations over a three-month test period. Optical data collected from coated and control surfaces were identical. The same observation was made by McLean et al (1996). The difference is that in their study they did not differentiate biofilm formation/microfouling from accumulation of abiotic materials. The present findings indicate that a more toxic material will not provide a solution for the short lifetime of optical sensors. Coatings can be prepared that will resist microbiological growth for short periods of time. However, biocides cannot control electrostatic interactions, flocculation, or strength of adhesion of surface-bound material. The operational lifetime of optical sensors might be lengthened by attempting to control the hydrophilicity/hydrophobicity rather than the toxicity of the surface. Loeb and Neihof (1975) used microelectrophoresis to demonstrate that particles in the marine environment, including bacteria and microalgae, are net negatively charged and attracted to positively-charged surfaces including glass. It is possible that surface charge interactions can account for the accumulations of colloidal material, marine snow and other non-living debris.

TRANSITIONS

Development of reliable optical sensors has several direct customers in the Mine Killer Program, Magic Lantern, and Magic Lantern-Adaptation (Coastal Systems Station/PMO-210).

REFERENCES

McLean, S., Schofield, B. Zibordi, G., Lewis, M., Hooker S., and Weidmann, A. Field Evaluation of Anti-Fouling Compounds on Optical Instrumentation. Ocean Optics 1996 SBIE Quarterly Proceedings.

Loeb, G and Neihof, R. Marine Conditioning Films In Applied Chemistry at Protein Interfaces Edited by R.E. Baier Advances in Chemistry Series 145 American Chemical Society Washington, D.C. 1975 pp319-335.

PATENTS

A patent application has been prepared for a device and technique for determining the force required to remove microfouling from surfaces using the ESEM. The application is in the NRL review process